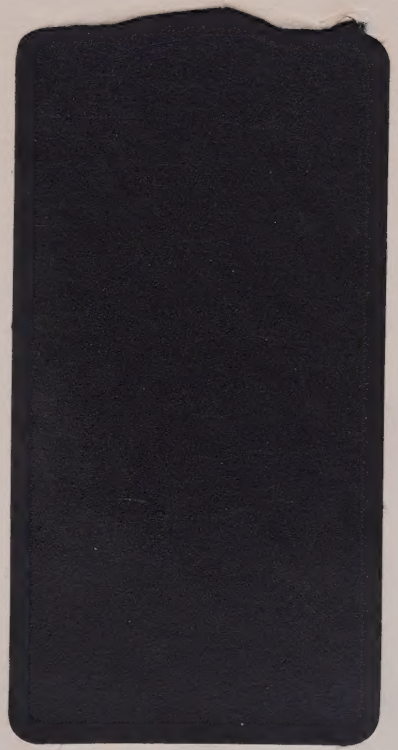
INSTRUCTION MANUAL

MODEL 414, 414C

MICRO-MICROAMMETER

KEITHLEY INSTRUMENTS



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SECTION I - INTRODUCTION

Model 414

The Keithley Model 414 Micro-microammeter is a line operated vacuum tube electrometer for measuring currents in the range of 2 micro-microamperes to 10 milliamperes. Features include a response speed of greater than 0.5 seconds on all ranges, an input drop of less than 5 millivolts at full scale, a zero drift of less than 2% per day on any range, good accuracy and calibration stability, negligible noise, and simplicity of operation. For recording, an output signal of five volts at 1 milliampere is available.

Model 414C

This model is identical to the 414 except that a meter-relay replaces the panel meter. An adjustable contact pointer is built into the meter-relay. When the indicating pointer rises to the value set with the adjustable contact, the contacts lock and actuate an internal relay. The relay's SPDT 5-ampere contacts are brought out through an AN connector at the back of the chassis.

A manual reset button is supplied on the front panel. Reset connections are also brought out through the AN connector for remote resetting of the locked-up meter-relay.

Any special instructions required for the Model 414C are found on page 3-2, paragraph 3.

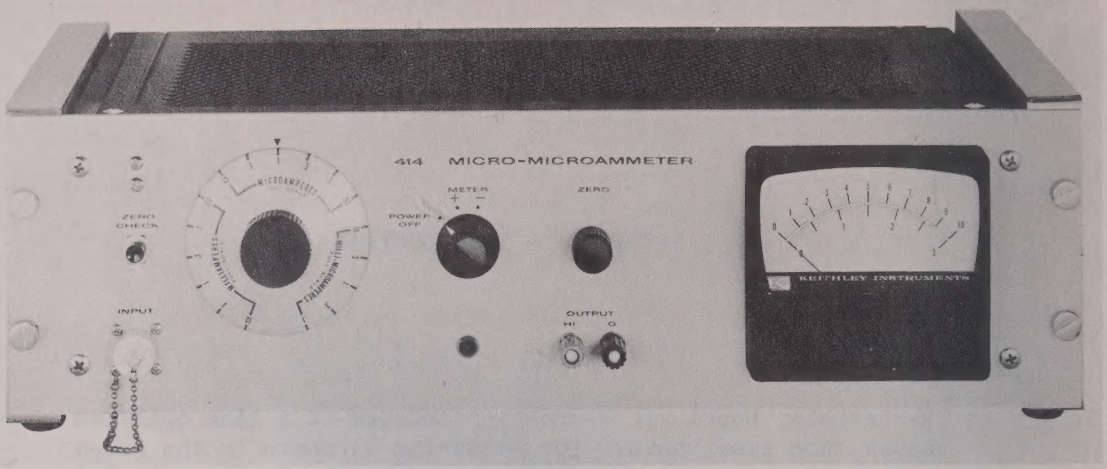


FIGURE 1. Keithley Model 414 equipped with End Frames for bench mounting.

FIGURE 2. Keithley Model 414C for rack mounting.

SECTION II - SPECIFICATIONS

RANGES: 17 ranges in overlapping 1 and 3 sequence, from 10 milliamperes to 0.1 milli-microampere full scale.

ACCURACY: Within 3% of full scale on all ranges from 10 milliamperes to 10 milli-microamperes, and within 4% of full scale from 3 milli-microamperes to 0.1 milli-microampere.

ZERO DRIFT: Less than 2% in any eight-hour period after a five minute warmup if the source voltage is not less than one volt.

GRID CURRENT: Negligible.

OUTPUT: A 5-volt output at up to 1 milliampere is developed for full scale meter deflections. Output noise is less than 1% peak-to-peak of full scale on any range, if the source voltage is not less than 1 volt.

INPUT DROP: Less than 5 millivolts for full scale on any range, with proper zero setting.

RESPONSE SPEED: Greater than 0.3 seconds for 90% of full scale on any range, with up to 5,000 micro-microfarads of input capacity.

Range in Amperes	Seconds to 63% of Final Current	
	No External Capacitance	With 5,000 μμf Across Input
10^{-10}	.11	.13
10^{-9}	.07	.07
10^{-8}	.06	.07
10^{-7}	.04	.05
10^{-6}	.02	.03
10^{-5}	.0004	.0006

ZERO CHECK SWITCH: Allows zeroing without disturbing the test circuit.

CONNECTORS: Input: Teflon-insulated UHF (Amphenol 83-798).
Output: Binding posts on front panel; Amphenol 80 PC2F at rear.

TUBE COMPLEMENT: One 5886, one 6BH8, one 6CM6, one OB2.

POWER: 100-130 (or 200 or 260) volts, 50-60 cps, 33 watts.

ACCESSORIES SUPPLIED: Mating connectors, 2-wire adapter for power cord.

ACCESSORIES AVAILABLE: Model 6032 End Frames, with mounting hardware and rubber feet.

DIMENSIONS: $5\frac{1}{4}$ inches high x 19 inches wide x 10 inches deep.

WEIGHT: 16 pounds.

SECTION III - OPERATION

A. OPERATING CONTROLS

1. Zero Check: This is a push-button located at the extreme left of the panel. Its function is to allow the zero of the instrument to be checked while the current source is attached. To use, depress and set the zero with ZERO Control. It is a feature of the instrument that the external circuit is not disturbed during the test.

2. Range Switch: The RANGE SWITCH is the dial next to and to the right of the ZERO CHECK button. The range in use is always at the top of the dial for convenient operation.

3. Power, Meter Reverse Switch: The knob to the right of the RANGE SWITCH is the power and meter polarity switch. This control permits positive or negative meter readings. The output voltage at the recorder terminals is not reversed by this switch.

4. Zero: This knob, next to the meter, is used in conjunction with the ZERO CHECK switch as described above to set the instrument zero.

B. OPERATION:

1. Precautions: If the instrument is to be used at its extreme sensitivity, it is necessary to shield all input leads. The lead-in cable should be polyethylene or teflon insulated coaxial cable; and a low noise, graphite-coated, dielectric cable such as Amphenol 21-537 is recommended. At low sensitivities some of these precautions may be disregarded.

2. Operation: (a) Connect to a power line of proper voltage. The instrument is shipped for 117 volt 50-60 cps operation. For 230 volt operation see circuit diagram at the rear of the manual.

(b) Turn the RANGE SWITCH to 10 milliamperes.

(c) Turn on power. After 30 seconds the instrument is ready to operate.

(d) Depress ZERO CHECK button and set meter to zero. CAUTION: Do not use control to set meter to any other point than zero.

(e) Instrument is now ready to operate. Attach current source and turn RANGE SWITCH to proper range.

3. Special Instructions for Contact Meter Models:

(a) The operation of the instrument is identical to the non-contact meter models with the exception that, on turn-on, the meter pointer will strike the meter contact and lock. Therefore, after the instrument is on for about one minute, press RESET button to release pointer and zero the meter. At this point proceed as in Sections 1 and 2.

(b) Special Output Connection: The output connector at the rear of the contact models is an AN connector which contains the output terminals, the control relay contacts and the resetting circuit. It is necessary that contacts A and B in the resetting circuit be shorted if the panel reset button is to be operative. If remote resetting is desired, terminals A and B may be connected through a remote normally closed switch. The wiring of this connector is shown in detail in DR1284-9C at the rear of the manual.

(c) The SPDT relay contacts are rated at 5 amperes at 110 volts AC or 24 volts DC.

4. Recording:

The Model 414 is provided with binding posts at the front of the instrument and a connector at the rear for connection to a recorder. A mating plug is provided for the rear connector. The wiring of the connector is shown in the schematics at the rear of the manual and is different for the 414 and the 414C.

The output is five volts at 1 milliampere for full scale meter deflection. The terminals may be connected directly to high impedance recording devices. A series resistor is necessary when driving a milliampere recorder or a mirror galvanometer. The exact value of resistance varies from recorder to recorder. For a one milliampere recorder, approximately 3.8 kilohms is required. The exact sensitivity may be set by means of a potentiometer in series with the output if desired.

5. Speed of Response:

The speed of response of the instrument is specified as not slower than 0.2 seconds for 67% of full scale with 5000 micro-microfarads of input capacity. Capacities greater than 5000 micro-microfarads may cause instability on some ranges. However, the above specifications allows up to 500 feet of 10 mmf per foot coaxial cable.

SECTION IV - CIRCUIT DESCRIPTION

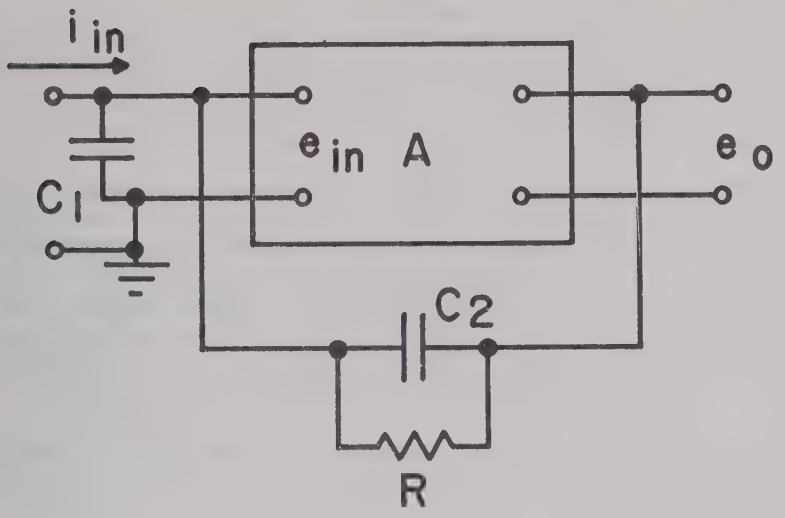


FIGURE 3. Basic micro-microammeter circuit

A. BASIC THEORY:

Figure 3 shows the basic circuit. The input current $\underline{i}$ flows into the input terminal. If we neglect C_1 and C_2 for the moment, the current $\underline{i}$ flows through R the feedback resistor. Since A is an amplifier of gain $\underline{k}$ and the feedback is negative.

$$e_{in} = e_o/k \quad (1)$$

and since all the current must flow through R,

$$i = \frac{-e_o + e_o/k}{R} \quad (2)$$

now if $\underline{k}$, the loop gain is large, the current flowing through the input is e_o/R and may be read from a properly calibrated meter at the output. e_{in} is the input drop of the ammeter.

The input resistance R_{in} is given by e_{in}/i and is,

$$R_{in} = \frac{R}{K+1} \quad (3)$$

Since in the Model 414, the amplifier gain k is about 1000, the input drop, e_{in} will be about 5 millivolts for a five volt output and the effective input resistance R_{in} will be about 1/1000 of the range resistor being used.

If the capacities C_1 and C_2 are considered, the time constant of the circuit is given by,

$$T = RC_1/k + RC_2$$

Thus the input time constant is reduced by a factor equal to the loop gain. Capacitor C_2 is placed across R to damp the response and prevent ringing.

B. CIRCUIT DESCRIPTION: Refer to DR127580 at the rear of the manual:

The input circuit consists of V1, a type 5886 electrometer tube, followed by a 6BH8 and a 6CM6 cathode-follower. This arrangement provides a loop gain of about 1000. A high degree of zero stability is assured by regulation of the filament supply of V1 and B+ supply by V4 the OA2 voltage regulator. The negative bias supply is regulated to the necessary degree by an NE81 neon lamp. The amplifier is a simple single ended direct-coupled amplifier. V1 and V2 are directly coupled and the coupling between V2 and V3 is by means of a NE81 neon lamp. R124, the zero control, operates by varying the screen potential of V1.

The current sensitivity is changed by either changing the feedback resistor (R100 through R113) or by changing the feedback voltage by means of resistors R116 and R117. From 10 milliampers to 10 milli-microamperes a feedback voltage of five volts is used and one resistor is used per range. From 3 milli-microamperes to 0.1 milli-microamperes one resistor is used per decade and the feedback voltage is either one or three volts depending on whether a 3x or 10x range is being used.

The power supply consists of a conventional rectifier-filter circuit for the positive and negative supplies.

SECTION V - MAINTENANCE

Except for occasional tube replacement very little maintenance is required for the Model 414. Components are operated well below rating, and high quality components have been used throughout.

1. FACTORY ADJUSTMENTS

Only one factory adjustment is made. This is R132, the meter calibration potentiometer. This adjustment is only necessary if the panel meter is changed. To calibrate set the instrument on the 1 or 10 milliampere range and set the meter to the correct reading with a calibration current sufficient to deflect the panel meter to at least 75% of full scale.

2. TROUBLE SHOOTING

Refer to DR12758-C and the voltage-resistance diagram at the rear of the manual.

Follow this general procedure in trouble shooting if the fault is not apparent from the tabulated list below:

1. Check the B+ and B- potentials: The B+ potential can be measured between the rectifier string and R201 and should be about 320 volts. The ripple should not exceed 3 volts rms. The B- potential may be measured between the negative rectifier string (RF4,5) and R205 and should be about 240 volts. The ripple again should not exceed 3 volts RMS. If either potential is not correct the trouble is probably due to a defective rectifier or filter component although in some cases the transformer may be defective. Refer to the schematic diagram to locate the defective component.

2. SPECIFIC FAULTS

a. Instrument will not balance: If no defect has been found after the inspection suggested in 1., check the voltage at pin 1 or 5 of V4. This should be 150 volts. If the voltage is not 150v, check R203, 202, and 201 for continuity and check V4. If the voltage is correct, check the voltage at pin 3 of V1 (The red dot is next to lead 1) the reading should be 3.2 volts. If the voltage at this point has risen to 150 volts, the filament of V1 is open and this tube should be replaced. If this voltage checks correctly, the following procedure should be started: Short circuit the input to ground with the range switch on 1 microampere full scale. This removes the negative feedback and allows the operating points of the individual tubes to be checked. It will usually be found that the amplifier will become very sensitive and difficult to balance, however it is only necessary that the voltage swing through the correct operating value to confirm that the circuit is operating correctly. Then with the input

shorted, measure the plate potential of V1 with a high impedance VTVM (100 megs or better). This voltage should be setable by means of the ZERO control to 8 volts. If it is not; either the electrometer tube is defective or the potential on the filament or screen is incorrect. We have already measured the potential on lead 3 of V1 and found it correct. Now measure the potential on lead 4. This should be 2.2 volts. If it is not check the value of R122, R123, R124, R208 and R204. Any of these could cause an incorrect voltage. The screen voltage on lead 2 is derived from R124 in the above resistor string. It should be possible to vary the screen voltage from approximately 5.4 to 10 volts. If this cannot be done, but the voltages are correct, R124 is defective or there is a short circuit to some other part of the printed board or harness. Finally remove V2 from its socket. If it is now possible to obtain the correct potential on the plate of V1, V2 is defective.

If it was possible to adjust the electrometer plate to 8 volts, V1 and its associated components are not at fault and it is necessary to proceed to V2, the 6BH8. Check the voltage at pin 2 of V2. This should be the same electrical point as lead 1 of V1 and by moving the zero control it should be possible to vary the potential at V2 precisely as on lead 1 of V1. If this is not possible, check for an open tape on the printed circuit board from V1 to V2. If everything checks to this point, measure the voltage on pin 9 of V2. The voltage should pass through 38 volts by varying the ZERO control. If this does not occur, check the other potentials on V2; if these are not correct look for a defective resistor or an open connection on the board. Finally check for a defective V2.

If no fault has shown up so far, proceed as follows: Check the potential at pin 3, V3, this should be setable with ZERO to about -8.3v. If this is not the case, check to see that GL1, the NE 81 is lit. Then remove V3 from the socket and check to see if now the correct potential can be obtained at pin 3, V3 or the lamp lights. If the potential can now be obtained with the zero control and the lamp lights, V3 may be defective or there may be a short to ground or B- from the cathode of V3. If the lamp does not now light, check R129 and if found good replace GL 1 with a new NE 81. If NE 81's are not available, most NE 2's will work in the circuit.

If the circuit did operate to this point, check V3 as suggested above. Then, if necessary, check for continuity of R130 the cathod load resistor and check to see that the potential at the bottom end of R129 is about -50 volts. Finally, check the potentials on the other electrodes of V3. If now it is possible to swing the output signal through zero volts with the ZERO control, the instrument should operate properly with the short to the input removed. If now this still is not

possible either the feedback connection is open or the circuit is oscillating. To check the feedback connection, check to see that lead 2 indicated on the circuit schematic is connected from the output cathode as shown. If the circuit works properly on some ranges but not on others, check to see if R117 and R116 are defective.

Oscillation in the circuit with the input connector capped (do not confuse with stray pickup) will be caused by a wrong or changed value of C101 or R126. Occasionally if a tube is replaced and the replacement has an unusually high gm, oscillation may occur. If this happens, try another tube or pad C101 so as to double its value.

b. Oscillation: If oscillation occurs, see the paragraph immediately above.

c. Inaccurate reading: For calibration procedure, see Section V 1 on FACTORY ADJUSTMENTS. If this adjustment is insufficient, be sure shielding of input is satisfactory before proceeding. The only other causes of inaccuracy are either insufficient loop gain or inaccurate feedback resistors. If the feedback resistor is at fault, the inaccuracy will be evident only on the range on which the resistor is being used. (CAUTION: when calibrating, using a resistor and a voltage source, the voltage should not be less than 0.1 volts.) The inaccuracy would then involve one of the resistors R100 to R113 or R116 and R117.

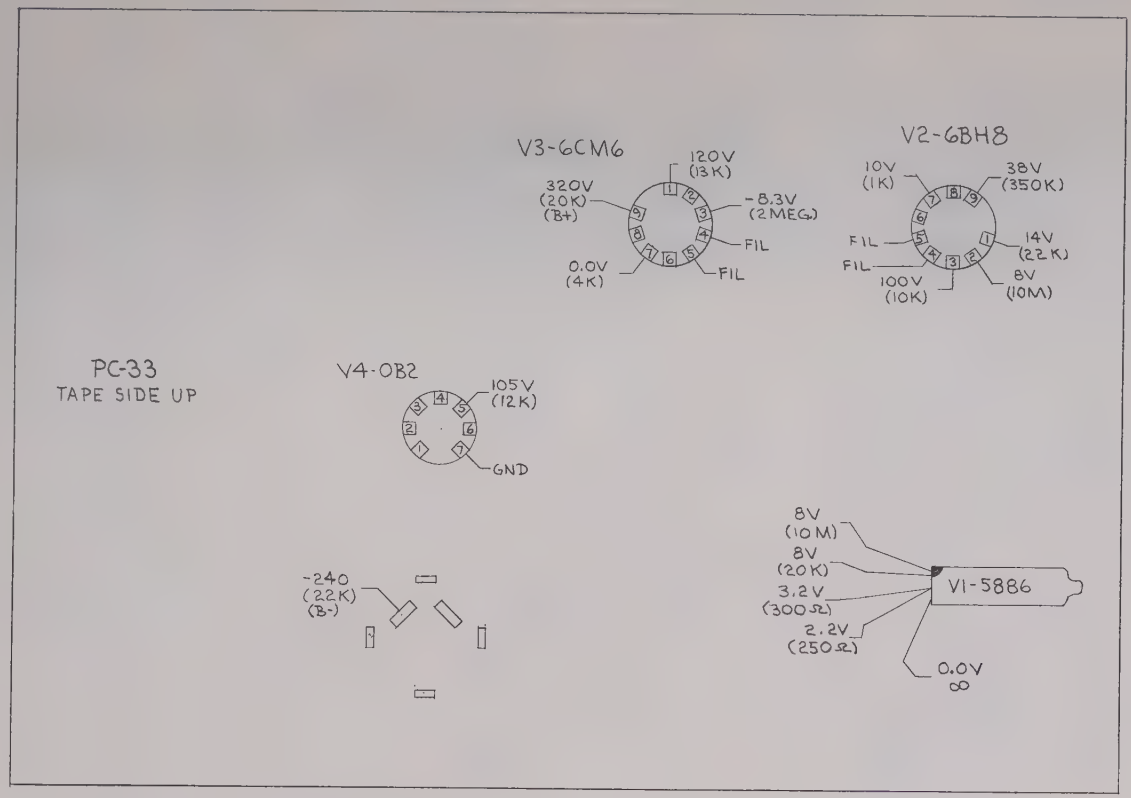
To check for low loop gain do the following: Turn the range switch to the 1 millimicroampere scale and connect a voltage source to the input whose impedance is not greater than 10K. The output will become relatively unstable, but with some care it should be possible to determine the DC voltage necessary at the input to cause a full scale meter deflection. If it requires more than about 5 millivolts to achieve full scale deflection, the loop gain is low. If no other symptons of malfunction occur, this can be remedied by replacing tubes.

Circuit Desig	Description	Part No.
C100	Capacitor, disc ceramic, 330 mmf, 600 WV, 10%	C22-330
C101	Capacitor, disc ceramic, .02 mf, 600 WV, 10%	C22-.02
C102	Capacitor, disc, ceramic, .001 mf, 600 WV, 10%	C22-.001
C103	Capacitor, disc ceramic, 330 mmf, 600 WV, 10%	C22-330
C104	Capacitor, disc ceramic, 330 mmf, 600 WV, 10%	C22-330
C105	Capacitor, disc ceramic, 330 mmf, 600 WV, 10%	C22-330
C106	Capacitor, disc ceramic, 330 mmf, 600 WV, 10%	C22-330
C107	Capacitor, disc ceramic, 330 mmf, 600 WV, 10%	C22-330
C108	Capacitor, disc ceramic, 150 mmf, 600 WV, 10%	C22-150
C109	Capacitor, disc ceramic, 100 mmf, 600 WV, 10%	C22-100
C110	Capacitor, disc ceramic, 330 mmf, 600 WV, 10%	C22-330
C111	Capacitor, polystyrene, 500 mmf 100 WV 25%	C31-500
C112	Capacitor, polystyrene, 50 mmf 100 WV, 25%	C31-50
C113	Capacitor, polystyrene, 5 mmf, 100 WV 25%	C31-5
C201A	Capacitor, electrolytic, 20 x 450 WV	C52-20
C201B	Capacitor, electrolytic, 20 x 450 WV	C52-2
C202	Capacitor, electrolytic, 20 x 600 WV	C35-20
C203	Capacitor, electrolytic, 20 x 450 WV	C8-201.
C204	Capacitor, ceramic, .002 mf, 600 WV 10%	C22-.02
R100	Resistor, dep. carbon, 500, 1%,	R12-500
R101	Resistor, dep. carbon, 1.67K, 1%, $\frac{1}{2}$w	R12-1.67K
R102	Resistor, dep. carbon, 5K, 1%, $\frac{1}{2}$w	R12-5K
R103	Resistor, dep. carbon, 16.7K, 1%, $\frac{1}{2}$w	R12-16.7K
R104	Resistor, dep. carbon, 50K, 1%, $\frac{1}{2}$w	R12-50K
R105	Resistor, dep. carbon, 167K, 1%, $\frac{1}{2}$w	R12-167K
R106	Resistor, dep. carbon, 500K, 1%, $\frac{1}{2}$w	R12-500K
R107	Resistor, dep. carbon, 1.67M, 1%, $\frac{1}{2}$w	R12-1.67M
R108	Resistor, dep. carbon, 5.0M, 1%, $\frac{1}{2}$w	R12-5.0M
R109	Resistor, dep. carbon, 16.7M, 1% 1w	R13-16.7M
R110	Resistor, dep. carbon, 50.0M, 1%, 2w	R14-50.0M
R 11	Resistor, dep. carbon, 100M 1%, 2w	R14-100M
R112	Resistor, High meg., 10^9 ohms, 3%	R20-10^9
R113	Resistor, High meg. 10^{10} ohms, 3%	R20-10^{10}
R115	Resistor, dep. carbon 1K 1% $\frac{1}{2}$w	R12-1K
R116	Resistor, dep. carbon, 2K 1% $\frac{1}{2}$w	R12-2K
R117	Resistor, dep. carbon 2K 1%, $\frac{1}{2}$w	R12-2K
R122	Resistor, dep. carbon 250 ohms, 1%, $\frac{1}{2}$w	R12-250
R123	Resistor, dep. carbon, 250 ohms, 1%, $\frac{1}{2}$w	R12-250
R124	Potentiometer W.W., 70K 4 watt	RP1-70K
R125	Resistor, dep. carbon, 10M 1% $\frac{1}{2}$ w	R13-10M
R126	Resistor, comp. carbon, 1K 10%, $\frac{1}{2}$w	R1-1K
R127	Resistor, comp. carbon, 22K 10%, $\frac{1}{2}$w	R1-22K
R128	Resistor, comp. carbon, 330K, 10%, $\frac{1}{2}$w	R1-330K
R129	Resistor, comp. carbon, 1M 10%, $\frac{1}{2}$w	R1-1M
R130	Resistor, wirewound, 18K, 10%, 10w	R5-18K
R131	Resistor, dep. carbon, 22K 1%, $\frac{1}{2}$w	R12-22K
R132	Potentiometer, W.W., 5K 4 watt	RP3-5K
R133	Resistor, dep. carbon, 500, 1%, $\frac{1}{2}$w	R12-500

Circuit Desig.	Description	Part No.
R201	Resistor, comp. carbon, 100 ohm, 10%, 2w	R3-100
R202	Resistor, wirewound, 10K, 10%, 10w	R5-10K
R203	Resistor, comp. carbon, 1.2K, 10%, 2w	R3-1.2K
R204	Resistor, wirewound, 10K, 10%, 5w	R4-10K
R205	Resistor, comp. carbon, 47 ohm, 10%, ½w	R1-47
R206	Resistor, comp. carbon, 1K, 10%, 1w	R2-1K
R207	Resistor, comp. carbon, 1M, 10%, ½w	R1-1M
R208	Resistor, comp. carbon, 1M, 10%, ½w	R1-1M
RF1	Selenium rectifier, 65 ma, 130 volt input	RF18
RF2	Selenium rectifier, 65 ma, 130 volt input	RF18
RF3	Selenium rectifier, 65 ma, 130 volt input	RF18
RF4	Selenium rectifier, 65 ma, 130 volt input	RF18
RF5	Selenium rectifier, 65 ma, 130 volt input	RF18
SW1	Meter reversing switch	SW70
SW2	Range switch, ceramic insulated	SW18
TR1	Transformer Primary #1 115v, 50/60 cy Primary #2 115v, 50/60 cy Secondary #1 325v, @ 40 ma Secondary #2 220v, @ 20 mas Secondary #3 6.3v@ 2 a Secondary #3 6.3v @ .6 a	TR23
V1	Electrometer tube,	EV5886-10
V2	Vacuum tube, Type 6BH8	EV6BH8
V3	Vacuum tube, Type 6CM6	EV6CM6
V4	Vacuum tube, Type OB2	EVOB2
FU1	Fuse 1.5 amp, Type 3AG	FU-8
ME1	Meter 0 - 200 Microamperes	ME-19
	Connectors On Chassis	
Input Connect.	Connector teflon insulated	CS-12
Output Termin.	Nylon (Two)	BP-13
Output Connect.	Microphone Type	CS-58
	Mating Plugs Furnished With Instruments	
Input Plug	Plug, teflon insulated	CS-49
Output Plug	Microphone Type	CS-33

REPLACEABLE PARTS LIST - MODEL 414C ONLY

Circuit Desig.	Description	Part No.
Output Connect.	Type AN3102A-18-1S	CS-23
C205	Capacitor, electrolytic, 1000 x 15 WV	C11-1000
RE1	SPDT 6 Volt AC Relay	RL7 or RL8
ME1	0-200 ma Model 461-26, Assembly Products	ME-20
RF6	Selenium Rectifier	RF-7
SW3	Pushbutton reset switch	SW-35
Output Plug	Type AN3102A-18-1S	CS-22

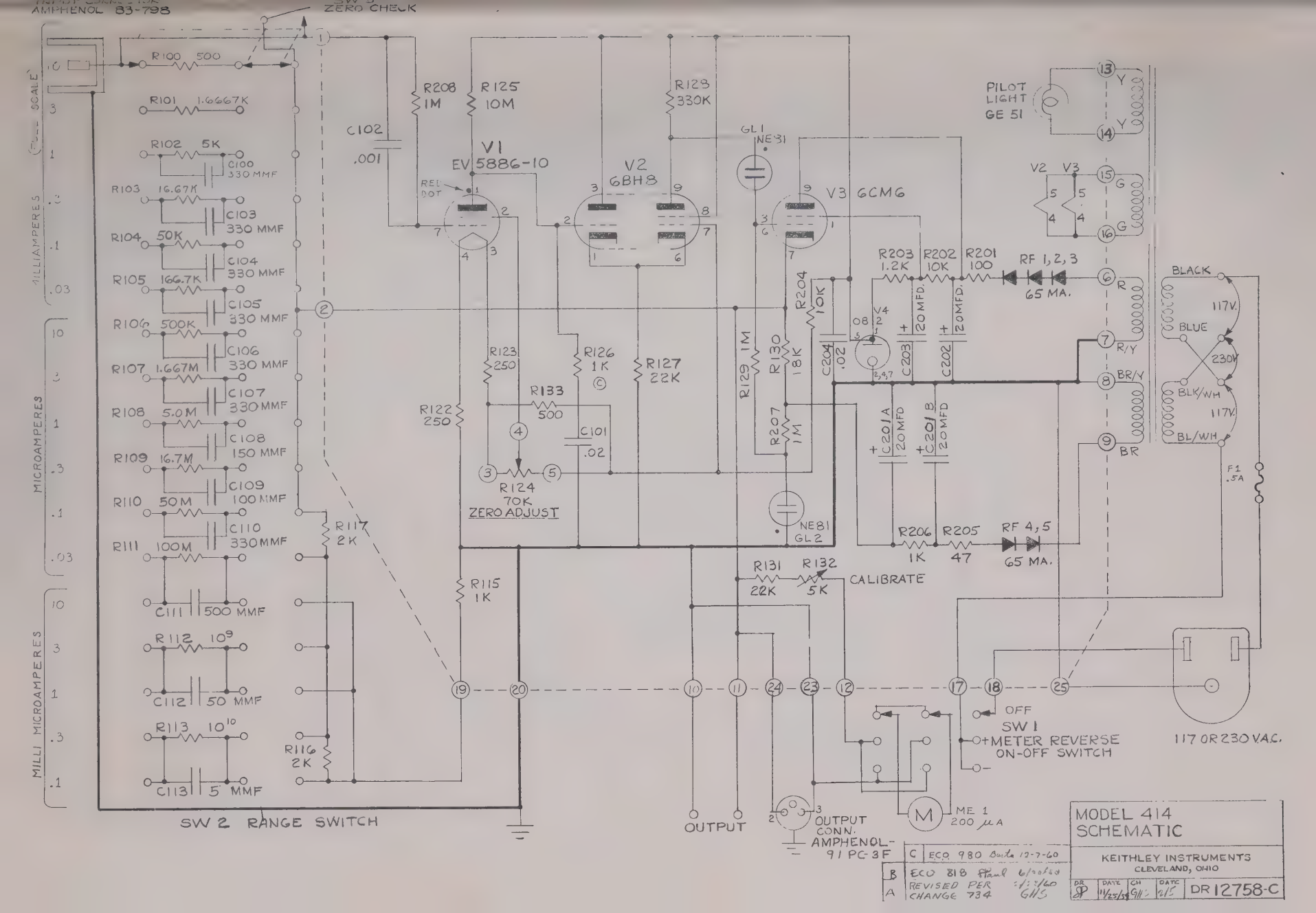


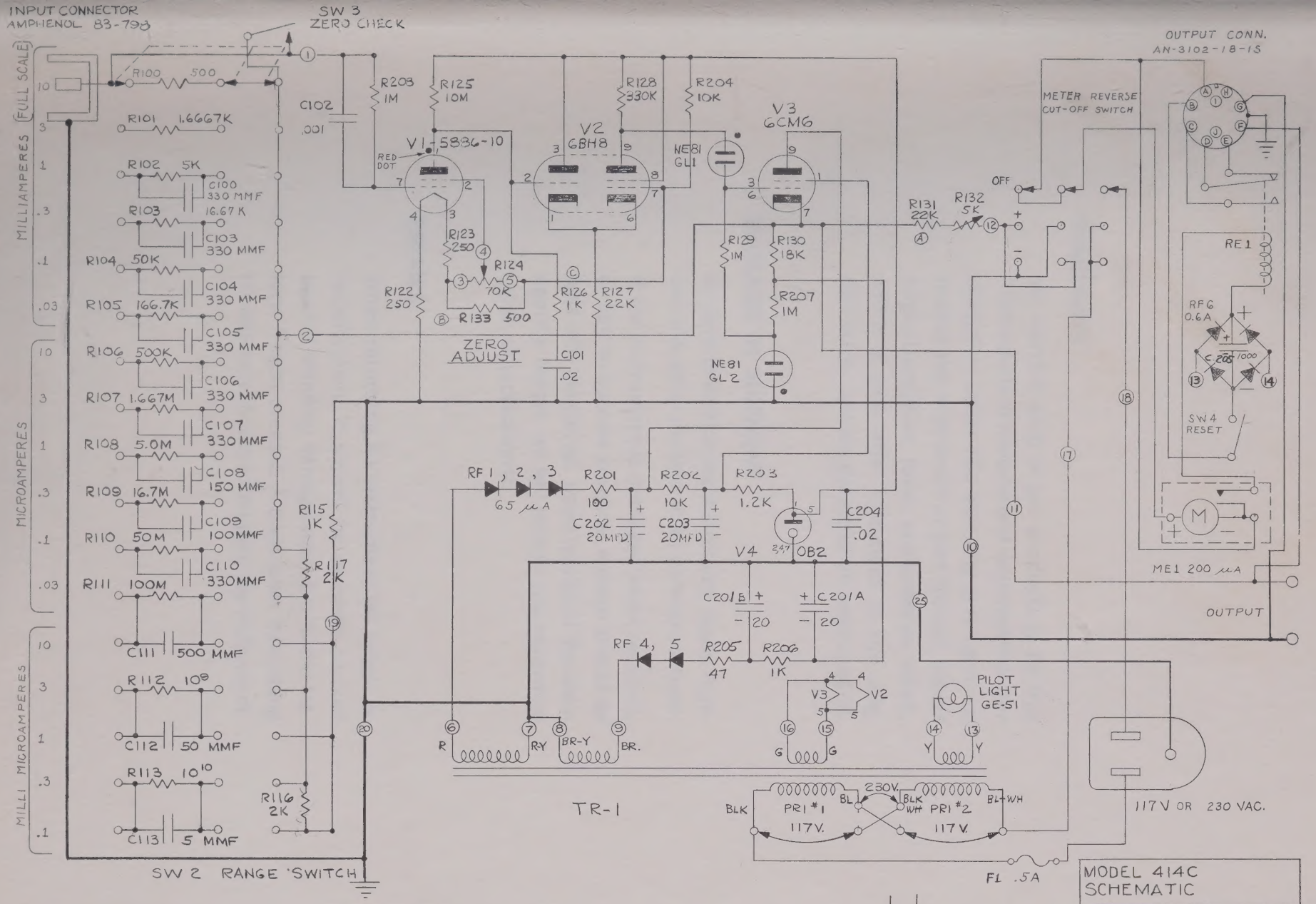
VOLTAGE AND RESISTANCE CHART
MEASURMENTS MADE FROM TUBE PIN TO
CHASSIS GROUND WITH CONTROLS SET AS FOLLOWS
OUTPUT ON PLUS
OUTPUT VOLTS ZERO
RANGE SWITCH AT 1×10^{-2} AMPS
MEASUREMENTS MADE WITH V.T.V.M WITH
100 MEGOHM INPUT IMPEDANCE

MODEL 414 & 414C
VOLTAGE & RESISTANCE CHART

KEITHLEY INSTRUMENTS
CLEVELAND, OHIO

DR	DATE	CH	DATE	DR 12764 -B
RTF	10/6/59	G.M.S	10/6/59	


AMPHENOL 83-798
ZERO CHECK
R100 500
R101 1.6667K
R102 5K
C100 330 MMF
R103 16.67K
C103 330 MMF
R104 50K
C104 330 MMF
R105 166.7K
C105 330 MMF
R106 500K
C106 330 MMF
R107 1.667M
C107 330 MMF
R108 5.0M
C108 150 MMF
R109 16.7M
C109 100 MMF
R110 50M
C110 330 MMF
R111 100M
C111 500 MMF
R112 10^9
C112 50 MMF
R113 10^10
C113 5 MMF
R116 2K
R117 2K
R115 1K
SW 2 RANGE SWITCH
MILLIAMPERES (FULL SCALE)
MICROAMPERES
MILLI MICROAMPERES
C102 .001
R208 1M
R125 10M
V1 EV 5886-10
RED DOT
V2 6BH8
R128 330K
GL1 NE31
V3 6CM6
PILOT LIGHT GE 51
V2 V3
R203 1.2K
R202 10K
R201 100
RF 1,2,3
65 MA.
R204 10K
C204 .02
V4 08
C203 20 MFD
C202 20 MFD
R123 250
R126 1K
R127 22K
R122 250
R133 500
C101 .02
R124 70K ZERO ADJUST
R129 1M
R130 18K
R207 1M
NE81 GL2
C201A 20 MFD
C201B 20 MFD
R206 1K
R205 47
RF 4,5
65 MA.
R131 22K
R132 5K
CALIBRATE
BLACK
117V.
BLUE
230V.
BLK/WH
117V.
BL/WH
F1 .5A
R
R/Y
BR/Y
BR
OFF
SW 1
+METER REVERSE
ON-OFF SWITCH
117 OR 230 VAC.
OUTPUT
OUTPUT CONN. AMPHENOL-91 PC-3F
ME 1 200 μA
C ECO 980 Date 12-7-60
B ECO 818 Final Updated
REVISED PER CHANGE 734
A
MODEL 414 SCHEMATIC
KEITHLEY INSTRUMENTS CLEVELAND, OHIO
DR 12758-C



C	ECO 980 Date 12-7-60	MODEL 414C SCHEMATIC				
B	ECO 818 KMK 6-30-60	KEITHLEY INSTRUMENTS CLEVELAND, OHIO				
A	REVISED PER CHANGE 734 SMC 2-23-60	DR SP	DATE 4/4/58	CH GNS	DATE 5/5	DR 2849-C

WARRANTY

We warrant each of our products to be free from defects in material and workmanship. Our obligation under this warranty is to repair or replace any instrument or part thereof, except tubes, transistors, fuses, and batteries, which, within a year after shipment to the original buyer, proves defective on examination.

DAMAGE IN SHIPMENT

Be sure to include the instrument model number and serial number in all communications.

If the instrument is damaged when received, or fails to operate properly, a claim should be filed with the carrier. Upon receipt of the claim agent's report, we will inform you regarding repair or replacement.

REPAIRS

When returning an instrument for repair or recalibration, it should be securely packed against shipping damage and sent to the factory, freight prepaid. A brief letter describing the difficulty should accompany the instrument.

KEITHLEY INSTRUMENTS, INC.
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